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SENIOR HIGH SCHOLL STUDENT'S METACOGNITIVE STRATEGIES IN TRIGONOMETRIC PROBLEM SOLVING

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Abstract

This research described the metacognitive strategy of three 10th grade students' based on students' mathematics ability, namely high, medium, and low as they worked on three trigonometric problems. They used as much time as they needed in solving each problem. Then data collection held in a one-to-one setting between the participant and the researcher, and concentrated on the participants' involvement in investigations of metacognitive strategy in trigonometric problem solving. They continuously thought aloud and engaged in a conversation describing their thinking and behaviours. The individual interviews took place shortly after the participants finished solving each problem where we talked comfortably about the participant's process of metacognitive strategy in trigonometric problem solving session. Based on the result of analysis, student with high mathematics ability did metacognitive strategy such as planning, monitoring, and evaluation. She could predict the correctness her work and detected her own mistake. Student with medium mathematics ability did metacognitive strategy such as planning and evaluation. She could detect her mistake but could not correct them into the right one. Students' metacognitive strategy with low mathematics ability not did monitoring and evaluation. He did his work well in full of confidence but there were a lot of mistakes that he could not detect. Based on the data analysis and discussion about the senior high school students' metacognitive strategy in trigonometric problem solving, this research is appropriate with the former researches that has been done such as research by Schoenfield (1987), Swanson (1990), Haidar & Naqabi et al (2008), and Java (2014). Furthermore, it can be concluded that the metacognitive strategy should be used to predict the successfulness of mathematical problem solving and to detect student mistake or misunderstanding while doing the task.
Keywords: metacognitive strategy, trigonometry, mathematics problem solving.

PRELIMINARY

Trigonometry is a mathematic subject who has attracted research attention due to its historical development and its current importance in mathematics education. Unfortunately, in fact, trigonometry is a subject that students have the most difficulty in understanding (Zengin, Furkan, & Kutluca, 2012), and students do not understand its benefits, historical usage, or application to daily life (Tuna & Kacar, 2013). One of the most important factors in trigonometry is the problem-solving strategy (Thompson, 2007). Hence, it is necessary to apply problem-solving approach in trigonometric learning.

Despite the emphasis given to mathematical problem solving, however, research by Schoenfield et al. (2013) showed that students' low problem-solving performance is not due to the inadequacy of mathematical content knowledge and facts, but rather is associated with students' inability to analyse the problem, to fully understand it, to evaluate the adequacy of given information, to organize knowledge and facts they possess with the goal of devising a plan, to evaluate the feasibility of the devised plan before its implementation, and to evaluate the reasonableness of the results. Hence, individual's awareness, consideration, and control of his or her own cognitive processes are held to be essential in mathematics problem solving (Kuzle, 2013). That awareness about the cognitive processes is called as metacognition.

The concept of metacognition introduced by Flavell in 1976, it defined as thinking about thinking, or a self-knowledge about the process of thinking (Livingston, 1997). Matlin (2005) said that metacognition is very helpful in arranging the environment and selecting a strategy to enhance cognitive abilities (Lestari, 2012). Connected with problem-solving, metacognition helps the problem solver to recognize the presence of a problem that needs to be solved, to discern what exactly the problem is, and understand how to reach the goal or solution (Kuzle,

2013). Therefore, metacognition is a critical component in cognitive function and cognitive development.

From the foregoing description, this research will conduct a study about how senior high school students' metacognitive strategy in trigonometric problem solving.

Based on the background described above, this research proposes following research question, "How are the senior high school students' metacognitive strategies in trigonometric problem solving?". The research purpose is to describe the senior high school students' metacognitive strategies in trigonometric problem solving. The result of this study may contribute to enrich the science about metacognition in problem solving especially in mathematics subject. This study is expected to to develop the student metacognitive skills and provide an overview for the teachers to apply the metacognitive strategy in learning process.

First will be discussed about what are the differences between cognition and metacognition also cognitive and metacognitive strategies.

Cognition vs. Metacognition

If metacognition is conceived as (knowledge of) a set of self-instructions for regulating task performance, then cognition is the vehicle of those self-instructions. These cognitive activities in turn are subject to metacognition, for instance, to ongoing monitoring and evaluation processes. This circular process of metacognitive and cognitive activities makes it hard to disentangle them in the assessment of metacognition.

Occasionally, metacognition can be observed in students' verbalized self-instructions, such as "this is difficult for me, let's do it step-by-step'' or "wait, I don't know what this word means.'' Metacognition, however, is not always explicitly heard or seen during task performance. Instead, it has often to be inferred from certain cognitive activities. For instance, doing things step-by-step may be indicative of planned behavior, although self-instructions for planning are not explicitly verbalized.

Cognitive vs. Metacognitive Strategies

Cognitive strategies are used to help an individual achieve a particular goal (e.g., understanding a text) while metacognitive strategies are used to ensure that the goal has been reached (e.g., quizzing oneself to evaluate one's understanding of that text). Metacognitive experiences usually precede or follow a cognitive activity. They often occur when cognitions fail, such as the recognition that one did not understand what one just read. Such an impasse is believed to activate metacognitive processes as the learner attempts to rectify the situation.

Metacognitive and cognitive strategies may overlap in that the same strategy, such as questioning, could be regarded as either a cognitive or a metacognitive strategy depending on what the purpose for using that strategy may be. For example, you may use a self-questioning strategy while reading as a means of obtaining knowledge (cognitive), or as a way of monitoring what you have read (metacognitive). Because cognitive and metacognitive strategies are closely intertwined and dependent upon each other, any attempt to examine one without acknowledging the other would not provide an adequate picture.

Metacognitive Strategies in Mathematics Problem Solving

O'Malley and Chamot's (2001) definition for metacognitive strategies is that "metacognitive strategies involve thinking about the learning process, planning for learning, and self-evaluation after the learning activity has been completed" (Lv & Chen, 2010). Based on information processing theory and procedural and declarative knowledge, O'Malley and Chamot (1990) classified metacognitive strategies into three categories: (1) planning, (2) monitoring, (3) evaluation. It is supported by a number of studies report significant improvement in learning when regulatory skills and an understanding of how to use these skills are included as part of classroom instruction. Therefore, it can be concluded that the metacognitive strategy to be used in classroom instruction is self-regulatory (i.e., regulation of cognition) processes, including **planning**, **monitoring**, and **evaluation**.

Polya (1981) stated that problem-solving is a process starting from the minute students is faced with the problem until the end when the problem is solved. Nevertheless, teachers should not simply help students solve a problem; instead, they should help them learn how to operate a process to solve a problem. Although students had difficulties in every episode during problem solving, they were able to use their metacognitive skills to detect the mistake or missing parts of the process and adapted themselves independently to make the required changes (Java, 2014).

The student's achievement in doing the problem-solving can be predicted by how their metacognitive skills are being used (Haidar & Naqabi et al., 2008). Swanson (1990) in his study concluded that metacognitive skill is a better predictor of student problem-solving success than their aptitude. Furthermore, Schoenfield (1987) said that metacognition has been found by some researches to be a key factor in successful problem solving. Therefore, metacognition plays a prominent role in problem solving.

RESEARCH METHOD

The objective of this research is to find out how is the students metacognitive strategies work in their solving trigonometric problem. The result will be presented as data of Mathematics Achievement Test (MAT) and Metacognition-Problem Solving Test (MPST). The

research has been done on X – MIPA 3 class at public senior high school in Sidoarjo on even semester 2016/2017.

The data collection occurred in a one-to-one setting between the participant and the researcher, and concentrated on the participants' involvement in investigations of metacognitive strategy in trigonometric problem solving (MPST). They continuously thought aloud and engaged in a conversation describing their thinking and behaviours. They used as much time as they needed in solving each problem. The individual interviews took place shortly after the participants finished solving each problem where we talked comfortably about the participant's process of metacognitive strategy in trigonometric problem solving session.

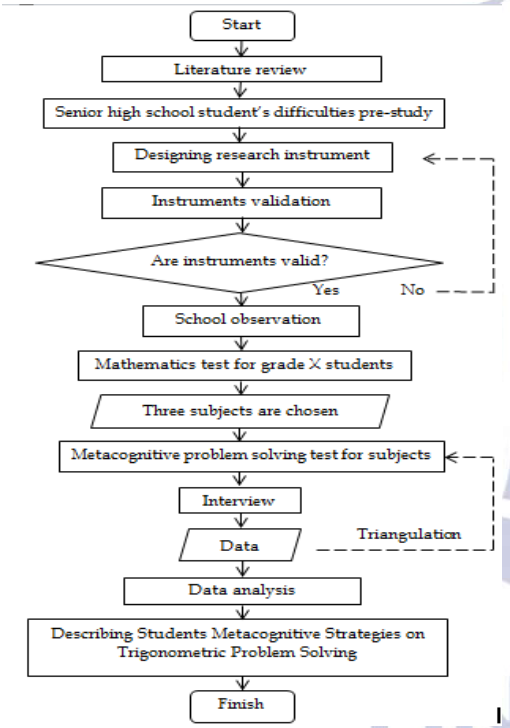

Figure 1. Research Design

The result of Mathematics Achievement Test (MAT) was analyzed by using scoring guidelines; meanwhile grades (high, medium, low) determining was analyzed by using standard deviation. Based on that data and suggestion from their mathematics teacher, one student from each grade was chosen for represent the whole data i.e. IM (high), DL (medium), and DA (low).

RESULT AND DISCUSSION

From the results of data analysis obtained, it indicate that there are significant differences in metacognitive strategy in trigonometric problem solving process which has been done by high, medium, and low grade subjects. The difference is seen from the work of subjects, interviews, and observations of researchers.

1. The First Subject Metacognitive Strategies Analysis (IM)

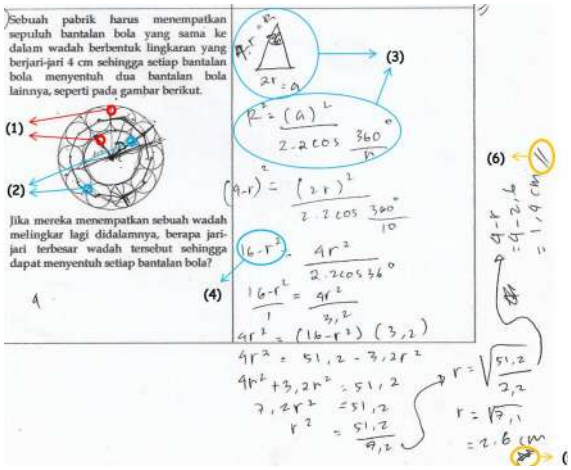

Figure 2. IM's Solution

Table 1. IM's Problem Solving Description

STUDENTS PROBLEM SOLVING DESCRIPTION	METACOGNITIVE PHASE
(1) After she did all problems, she backed to 2nd problem. She read the problem slowly and observed the picture. She drew a line to connect the center with an arc which was touch one little circle until form new plane pizza piece in shape inside the circle. She drew one pizza piece in shape plane on the scratch sheet and made a bowstring. (2) She thought about connection between bowstring and radius of little circle. Then she connected the bowstring with the circumference of the big circle.But, she got failed to find out the connection.	Planning
(3) Researcher directed her drew a line to connect center of little circle to another center and a triangle which was form by them and the center of big circle. She understood the initial way to solve the problem. (4) Researcher gave the formula to find the radius. She executed the formula by substituting the angle and side of triangle. In 4th line of solution, she made a mistake and it impacted to the	Monitoring

STUDENTS PROBLEM SOLVING DESCRIPTION	METACOGNITIVE PHASE
(5) She wrote the solution into question sheet.She marked the radius with one pair parallel line meanwhile it was not the goal of the problem. (6) Researcher reminded her to re-read the problem. She wrote the goal of the problem. She marked the final solution with one pair parallel line.	Evaluation

During problem solving activities, subject was really aware to her cognitive ability from the first time she did the test. She felt confident with her performance and knew how well she had done. Although she made some mistakes on her work, she still held her performance. When she realized her own mistake, her metacognitive strategies was shown up gradually. Nevertheless, she did metacognitive strategy, planning, monitoring, and evaluation, but she did not realize it.

Planning. Subject planning strategy was seen from her ability in preparing the plan before working on the problem. She analysing the problem and its relation with the problem ever done. She did initial understanding well on the problem. For instance, she writes down the known and makes the picture.

Monitoring. Subject did monitoring strategy but still needs to be improved more. This is clear seen from some subject activities that show monitoring strategy. She realizes that her cognitive abilities are quite high. She checks his work periodically and assessing her plan whether it has answered the goal or not.

Evaluation. Almost all the initial answer of the subject is written on the scratch sheet. When she feels sure with her solution then she copy them into the space provided. It shows subject evaluation strategy is quite good. On other side, the subject also show another evaluation strategy that is assesses whether the final work is in line with the objectives, examines the learning process itself, makes the decision to accept or process solutions.

2. The Second Subject Metacognitive Strategies Analysis (DL)

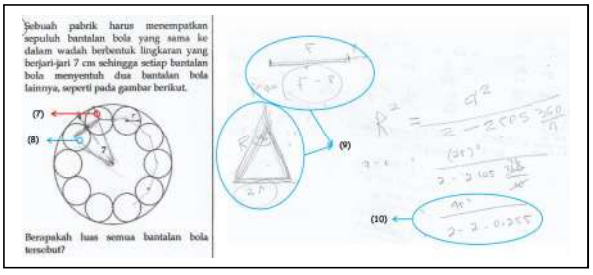

Figure 3. DL's Solution

Table 2. DL's Problem Solving Description

STUDENTS PROBLEM SOLVING DESCRIPTION	METACOGNITIVE PHASE
7) She said to researcher that cannot solve the problem. Researcher asked her reason; she explained that did not know the right way to solve the problem especially on illustrating the problem. Researcher provided her to make an illustration on the image. She tried to connect the center of big circle into the arc throw the small circle center. 7 8) Researcher checked her work then she made the right one. She drew the triangle out of the circle in order to find r easier. 9) Researcher told her the formula to calculate the small circle radius. She continued do the task but stopped when faced the quadratic formula in her work because she felt tired.	Planning

From the beginning subject do the problem, she is not confident in her own cognitive abilities. She is afraid of making mistakes and is unwilling to work in very difficult problems (on her thought). Nevertheless she keeps trying to think out how to solve them. She actually knows that her work is wrong but she does not know the right one. After working half of test, she feels confident about her performance and her metacognitive strategy grow up gradually even though she did not notice it.

Planning. Subject did planning strategy but she needs to improve them. It caused by her weakness which is not able to make relation between the known and the purpose of the question. So her plans that she has developed are often wrong. In other words, she can make plans but does not know whether the plan is the right plan or not.

Monitoring. Actually subject did monitoring strategy and it viewed from the indicators that are shown. She can found themselves analyzing the usefulness of strategies while study However, she cannot make other plans and choose the most correct one then in general it is not very good. The foundation of monitoring strategy already exists but still needs to be developed more.

Evaluation. Subject shows almost all the evaluation indicators during the problem solving process. No doubt that subject did evaluation strategy well. For instance knowing how well she did once finish a test, summarizing what she has learnt, learning new knowledge, etc. However, she has an inability in making decision to accept the solution or not.

3. The Third Subject Metacognitive Strategies Analysis (DA)

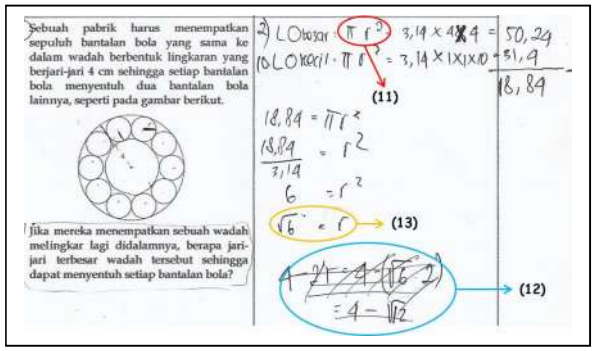

Figure 4. DA's Solution

Table 3. DA's Problem solving Description

STUDENTS PROBLEM SOLVING DESCRIPTION	METACOGNITIVE PHASE
(11) He read the problem information and understanding it but skipped the question sentence. He wrote the area of circle formula directly because of his thought i.e. the goal of the problem was determine the area of deepest circle. He moved the next problem however researcher checked his work. Researcher asked him to explain about his solution.	Planning
(12) He thought that the diameter of small circle was half of the radius of big circle so he determined directly $r = 1$ cm. Researcher asked him again to make sure his answer, "Are you sure? How do you believe that is the right answer?". He said, "Yes I'm, because it is clearly seen in the picture". Researcher asked about the problem, "Are you sure that your solution is the problem goal?" then he re-read the problem and found the mistake.	Monitoring

At first test, subject does not show any metacognitive strategy at all. He is too lazy in understanding the purpose of problem instruction so that he has a very fatal misconception. When he finishes the problem, researcher provokes him to use his metacognitive strategy to judge his solution is right or not. However, the subject remains in his mind and he feels very sure on his solution that it is the right one. Subject is very confident in his abilities despite that there are many mistakes in his work. Researcher provokes him by giving some question then gradually he shows his metacognitive strategy. At the next test, his starting point on the problem solving process still does not show the metacognitive strategy. But after half the process, researcher tries to provide some questions so that he is able to develop his own metacognitive strategy.

Planning. Subject did not try to understand the instructions and was lazy to think what really need to learn. Therefore, researcher provoked him to show up that strategy by providing some questions which were expected to generate his planning strategy. It slowly began to grow when he worked on the last problem; he really showed the planning strategy.

Monitoring. Subject did monitoring strategy because he was absolutely sure of his thoughts and was very difficult to change it. Despite that, at the time when he got some helps from researcher, he thought that his work was definitely correct. Hence, he did not review and recheck his work anymore. That was why his monitoring strategy not grows up anymore.

Evaluation. In general, subject did metacognitive strategy from the first test to the second test but he did not the evaluation strategy. It was his weakness after all due to his over confidence on his performance or researcher help. Nevertheless, at last he had learnt as much as he could have once finished all tasks.

WEAKNESS

This study has a weakness here and there because researcher conducted an interview after all subjects finished the test. Student awareness of their metacognitive strategy while performing the test and after performing the test is different. The interview should be done when subject end the problem solving process and does not wait for all the questions to be completed. Subject observation should be performed by more than one researcher in order to getting more valid data. So the data obtained in the form of metacognitive strategy that has done by subject in mathematical problem solving process more accurate and can be took for the responsibility.

CONCLUSION

Based on the data analysis and discussion about the senior high school students' metacognitive strategy in trigonometric problem solving can be concluded that this research is appropriate with the former researches that has been done such as research by Schoenfield (1987), Swanson (1990), Haidar & Naqabi et al (2008), and Java (2014). Schoenfield (1987) said that metacognition has been found by some researches to be a key factor in successful problem solving. Swanson (1990) in his study concluded that metacognitive skill is a better predictor of student problem-solving success than their aptitude. Haidar & Naqabi et al. (2008) stated that the student's achievement in doing the problem-solving can be predicted by how their metacognitive skills are being used. The last, Java (2014) in his result said that although students had difficulties in every episode during problem solving, they

were able to use their metacognitive skills to detect the mistake or missing parts of the process and adapted themselves independently to make the required changes. Furthermore, it can be concluded that the metacognitive strategy should be used to predict the successfulness of mathematical problem solving and to detect student mistake or misunderstanding while doing the task.

SUGGESTION

Based on the research that has been done, the researcher put forward some suggestions as follows.

1. Based on the research results that show the differences of metacognitive strategy by high, medium, and low grades subject, it is recommended for educators to give student a feedback in the form of questions that can stimulate students to think by involving their metacognitive strategy when faced mathematics problem solving.
2. For educators, it is recommended to design learning activities that can develop students' metacognitive strategy in mathematics problem solving.
3. For other researchers interested in conducting similar research, should examine more deeply about the metacognition of students but on different views such as the role of cognition and metacognition in the problem solving process.

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